WCDMA FOR UMTS

Radio Access For Third Generation Mobile Communications

Edited by
Harri Holma and Antti Toskala
Both of Nokia, Finland

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that accelerates and facilitates its introduction, and enables such competitive advantages as global roaming.

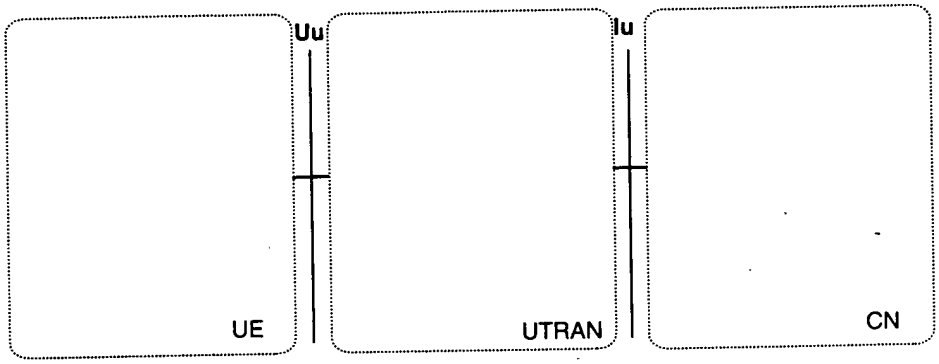

Figure 5.1. UMTS high-level system architecture

Another way to group UMTS network elements is to divide them into sub-networks. The UMTS system is modular in the sense that it is possible to have several network elements of the same type. In principle, the minimum requirement for a fully featured and operational network is to have at least one logical network element of each type (note that some features and consequently some network elements are optional). The possibility of having several entities of the same type allows the division of the UMTS system into sub-networks that are operational either on their own or together with other sub-networks, and that are distinguished from each other with unique identities. Such a sub-network is called a UMTS PLMN (Public Land Mobile Network). Typically one PLMN is operated by a single operator, and is connected to other PLMNs as well as to other types of networks, such as ISDN, PSTN, the Internet, and so on. Figure 5.2 shows elements in a PLMN and, in order to illustrate the connections, also external networks.

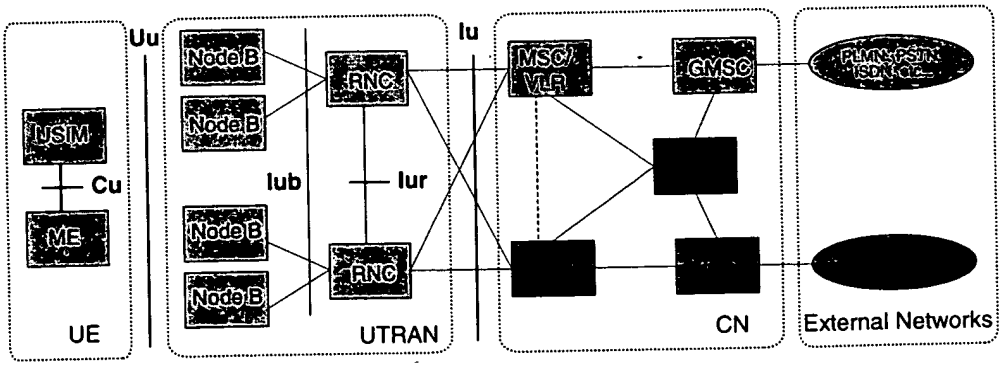

Figure 5.2. Network elements in a PLMN

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External Networks

The UTRAN architecture is presented in Section 5.2. A short introduction to all the elements is given below.

The UE consists of two parts:

- The Mobile Equipment (ME) is the radio terminal used for radio communication over the Uu interface.
- The UMTS Subscriber Identity Module (USIM) is a smartcard that holds the subscriber identity, performs authentication algorithms, and stores authentication and encryption keys and some subscription information that is needed at the terminal.

UTRAN also consists of two distinct elements:

- The Node B converts the data flow between the Iub and Uu interfaces. It also participates in radio resource management. (*Note that the term 'Node B' from the corresponding 3GPP specifications is used throughout Chapter 5. The more generic term 'Base Station' used elsewhere in this book means exactly the same thing.*)
- The Radio Network Controller (RNC) owns and controls the radio resources in its domain (the Node Bs connected to it). RNC is the service access point for all services UTRAN provides the CN, for example management of connections to the UE.

The main elements of the GSM CN (there are other entities not shown in Figure 5.2, such as those used to provide IN services) are as follows:

- HLR (Home Location Register) is a database located in the user's home system that stores the master copy of the user's service profile. The service profile consists of, for example, information on allowed services, forbidden roaming areas, and Supplementary Service information such as status of call forwarding and the call forwarding number. It is created when a new user subscribes to the system, and remains stored as long as the subscription is active. For the purpose of routing incoming transactions to the UE (e.g. calls or short messages), the HLR also stores the UE location on the level of MSC/VLR and/or SGSN, i.e. on the level of serving system.
- MSC/VLR (Mobile Services Switching Centre/Visitor Location Register) is the switch (MSC) and database (VLR) that serves the UE in its current location for Circuit Switched (CS) services. The MSC function is used to switch the CS transactions, and the VLR function holds a copy of the visiting user's service profile, as well as more precise information on the UE's location within the serving system. The part of the network that is accessed via the MSC/VLR is often referred to as the CS domain.
- GMSC (Gateway MSC) is the switch at the point where UMTS PLMN is connected to external CS networks. All incoming and outgoing CS connections go through GMSC.

- SGSN (Serving GPRS (General Packet Radio Service) Support Node) functionality is similar to that of MSC/VLR but is typically used for Packet Switched (PS) services. The part of the network that is accessed via the SGSN is often referred to as the PS domain.

- GGSN (Gateway GPRS Support Node) functionality is close to that of GMSC but is in relation to PS services.

The external networks can be divided into two groups:

- CS networks. These provide circuit-switched connections, like the existing telephony service. ISDN and PSTN are examples of CS networks.

- PS networks. These provide connections for packet data services. The Internet is one example of a PS network.

The UMTS standards are structured so that internal functionality of the network elements is not specified in detail. Instead, the interfaces between the logical network elements have been defined. The following main open interfaces are specified:

- Cu Interface. This is the electrical interface between the USIM smartcard and the ME. The interface follows a standard format for smartcards.

- Uu Interface. This is the WCDMA radio interface, which is the subject of the main part of this book. The Uu is the interface through which the UE accesses the fixed part of the system, and is therefore probably the most important open interface in UMTS. There are likely to be many more UE manufacturers than manufacturers of fixed network elements.

- Iu Interface. This connects UTRAN to the CN and is introduced in detail in Section 5.4. Similarly to the corresponding interfaces in GSM, A (Circuit Switched) and Gb (Packet Switched), the open Iu interface gives UMTS operators the possibility of acquiring UTRAN and CN from different manufacturers. The enabled competition in this area has been one of the success factors of GSM.

- Iur Interface. The open Iur interface allows soft handover between RNCs from different manufacturers, and therefore complements the open Iu interface. Iur is described in more detail in Section 5.5.1.

- Iub Interface. The Iub connects a Node B and an RNC. UMTS is the first commercial mobile telephony system where the Controller–Base Station interface is standardised as a fully open interface. Like the other open interfaces, open Iub is expected to further motivate competition between manufacturers in this area. It is likely that new manufacturers concentrating exclusively on Node Bs will enter the market.

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5.2 UTRAN Architecture

UTRAN architecture is highlighted in Figure 5.3.

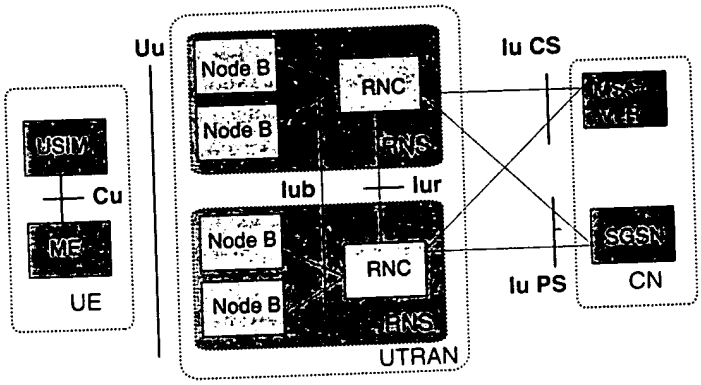

Figure 5.3. UTRAN architecture

UTRAN consists of one or more Radio Network Sub-systems (RNS). An RNS is a sul network within UTRAN and consists of one Radio Network Controller (RNC) and one more Node Bs. RNCs may be connected to each other via an Iur interface. RNCs and No Bs are connected with an Iub Interface.

Before entering into a brief description of the UTRAN network elements (in th section) and a more extensive description of UTRAN interfaces (in the following section we present the main characteristics of UTRAN that have also been the main requiremer for the design of the UTRAN architecture, functions and protocols. These can summarised in the following points:

- *Support of UTRA* and all the related functionality. In particular, the major impact the design of UTRAN has been the requirement to support *soft handover* (one termi connected to the network via two or more active cells) and the WCDMA-speci *Radio Resource Management* algorithms.

- Maximisation of the *commonalities in the handling of packet-switched and circ switched data*, with a unique air interface protocol stack and with the use of the sa interface for the connection from UTRAN to both the PS and CS domains of the c network.

- Maximisation of the *commonalities with GSM*, when possible.

- Use of the *ATM transport* as the main transport mechanism in UTRAN.

5.2.1 *The Radio Network Controller*

The RNC (Radio Network Controller) is the network element responsible for the contro the radio resources of UTRAN. It interfaces the CN (normally to one MSC and one SG

and also terminates the RRC (Radio Resource Control) protocol that defines the messages and procedures between the mobile and UTRAN. It logically corresponds to the GSM BSC.

5.2.1.1 Logical Role of the RNC

The RNC controlling one Node B (i.e. terminating the Iub interface towards the Node B) is indicated as the *Controlling RNC* (CRNC) of the Node B. The Controlling RNC is responsible for the load and congestion control of its own cells, and also executes the admission control and code allocation for new radio links to be established in those cells.

In case one mobile–UTRAN connection uses resources from more than one RNS (see Figure 5.4), the RNCs involved have two separate logical roles (*with respect to this mobile–UTRAN connection*):

- *Serving RNC.* The SRNC for one mobile is the RNC that terminates both the Iu link for the transport of user data and the corresponding RANAP signalling to/from the core network (this connection is referred to as the RANAP connection). The SRNC also terminates the Radio Resource Control Signalling, that is the signalling protocol between the UE and UTRAN. It performs the L2 processing of the data to/from the radio interface. Basic Radio Resource Management operations, such as the mapping of Radio Access Bearer parameters into air interface transport channel parameters, the handover decision, and outer loop power control, are executed in the SRNC. The SRNC may also (but not always) be the CRNC of some Node B used by the mobile for connection with UTRAN. One UE connected to UTRAN has one and only one SRNC.

- *Drift RNC.* The DRNC is any RNC, other than the SRNC, that controls cells used by the mobile. If needed, the DRNC may perform macrodiversity combining and splitting. The DRNC does not perform L2 processing of the user plane data, but routes the data transparently between the Iub and Iur interfaces, except when the UE is using a common or shared transport channel. One UE may have zero, one or more DRNCs.

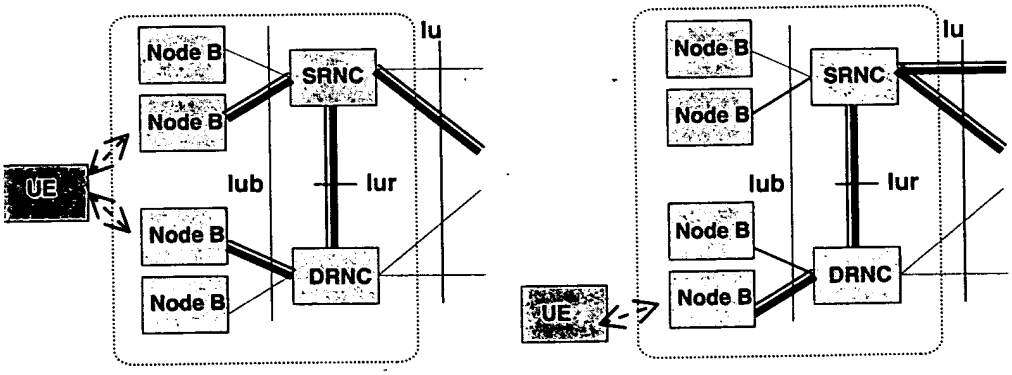

Figure 5.4. Logical role of the RNC for one UE UTRAN connection. The right-hand scenario shows one UE in inter-RNC soft handover (combining is performed in the SRNC). The left-hand scenario represents one UE using resources from one Node B only, controlled by the DRNC

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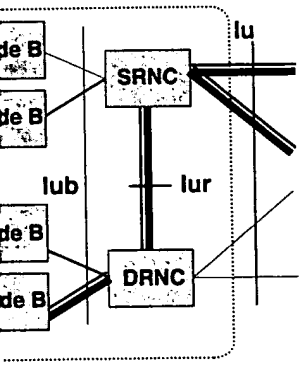

The right-hand scenario shows
RNC). The left-hand scenario
trolled by the DRNC

Note that one physical RNC normally contains all the CRNC, SRNC and DRNC functionality.

5.2.2 The Node B (Base Station)

The main function of the Node B is to perform the air interface L1 processing (channel coding and interleaving, rate adaptation, spreading, etc.). It also performs some basic Radio Resource Management operation as the inner loop power control. It logically corresponds to the GSM Base Station. The enigmatic term 'Node B' was initially adopted as a temporary term during the standardisation process, but then never changed.

The logical model of the Node B is described in Section 5.5.2.

5.3 General Protocol Model for UTRAN Terrestrial Interfaces

5.3.1 General

Protocol structures in UTRAN terrestrial interfaces are designed according to the same general protocol model. This model is shown in Figure 5.5. The structure is based on the principle that the layers and planes are logically independent of each other, and if needed, parts of the protocol structure may be changed in the future while other parts remain intact.

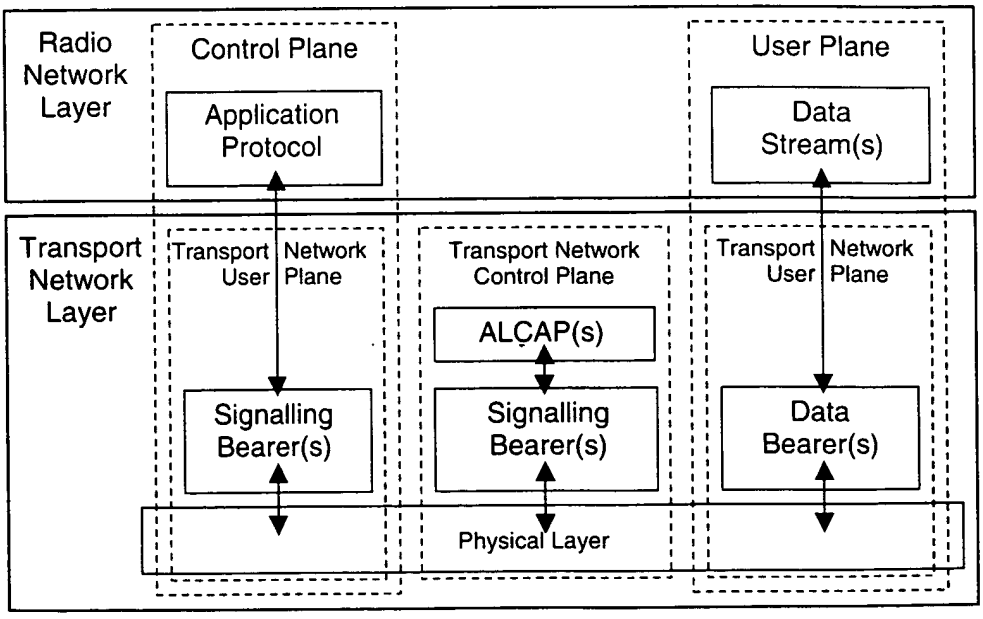

Figure 5.5. General protocol model for UTRAN terrestrial interfaces